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INTRODUCTION

The first ventilation system in the House of Commons, completed as part Charles Barry's architectural scheme for the New Palace of Westminster in 1852, was developed by the Scottish physician David Boswell Reid (1805-63). Reid, referred to as the 'ventilator', was originally employed by the Department of Woods and Forests to develop a ventilation scheme for the entire Palace. This early scheme was discard after six year. In 1846 the responsibilities for the ventilation, except for that in the House of Commons, was transferred to Barry. The ventilation in the House of Commons was the only part of Reid's original scheme that was realized and it was only operational for two years until it was decommissioned and replaced with a new system. The last remaining physical remnants of Reid's original system were ultimately destroyed by the Luftwaffe in 1941. The current debating chamber, designed by the architect Giles Gilbert Scott at the end of the war, is equipped with a modern air-conditioning and ventilation system by the mechanical engineer Oscar Faber.\(^1\) Except from fragments of the original air supply channels inside the roof and basement, none of original physical features have survived.\(^2\)

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\(^1\) GB. Parliament. 1843-44, p. 6. Oscar Faber's scheme is shown in early drawings from July 1944 (Faber, O and Scott G G, Ventilation and Air Conditioning scheme, July 1944, HLRO: ARC/PRO/WORK11/425) and in the working drawings for his final scheme of 1951 (PED)

\(^2\) The author has undertaken surveys of the remaining physical features in the House of Commons as part of his involvement in the Palace of Westminster Restoration and Renewal Programme.
Whilst it could be argued that Reid’s original system was an unsuccessful and short-lived experiment, this article intends to show that he accomplished a highly complex and sophisticated system that was the outcome of extensive inquiries into technical, environmental and human aspects of ventilation and climate control.

These included experiments with full-scale temporary structures, which began in spring 1836 with the construction of a physical model of the debating chamber in Edinburgh and were continued in Westminster, this time under real-life conditions, inside the Temporary House of Commons and the Temporary House of Lords. These Houses were erected by the architect Robert Smirke in 1834, a few months after a fire had destroyed the original medieval Palace, to provide parliament with provisional accommodation. These experimental inquiries were followed by the development of Reid’s first but unrealized scheme, in which the House of Commons formed integral part of a central ventilation system servicing the entire Palace of Westminster. This earlier scheme represents an important link between experimental inquiries and Reid’s final scheme for the Permanent House of Commons. This link has received little recognition in the existing literature. 3 Although Palace is widely recognized as an important building within the history of environmental technology, 4 neither Reid’s early proposal nor the final design for the Permanent Houses of Commons have been studied in any depth before. 5 The work of architectural historians 6 and historians of environmental design 7 have focused primarily on the overarching concept behind Reid’s early masterplan, whilst the sophisticated arrangements inside the House of Commons has remained largely uninvestigated.

This article provides a detailed reconstruction of the lost system inside the House of Commons and retraces its evolution, using original archival material, such as letters, sketches, architectural plans, technical reports and parliamentary paper. 8 In addition, historic

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3 A short paper on Reid’s system inside the Permanent House of Commons has been presented by the author at the Construction History Conference: Schoenefeldt H 2015, 167-82.
6 Port M H 1976, 218-31
7 Lerum V 2016, 54-62
8 This article is based on archival material held by Cambridge University Library, UCL, RIBA, National Art Library, British Library, National Archives, Parliamentary Archives and Parliamentary Estate Directorate.
measurements, eyewitness accounts and reports of scientific experiments, are used to
reconstruct the climatic and atmospheric conditions inside the chamber and how scientists,
engineers and MPs were involved in empirical evaluation of the system. It offers a new
perspective on study of historic buildings by illuminating how architectural technology in the
mid-nineteenth century was evaluated based on environmental criteria. Although
environmental factors, such as climate or air purity, are more transient dimensions of
architecture, they were part of the physical reality that affected the MPs’ experience of the
chamber from the perspective of thermal comfort and air quality. As the objective behind the
development of the sophisticated system was to enhance the MPs’ personal experience, the
state of the internal environment became the primary criteria in the evaluation of its
performance, and a deciding factor in the decision to decommissioning Reid’s system after
two years. The Ventilator
The process underlying the development of the system was strongly influenced by a scientific
perspective. David Boswell Reid did not have a background an engineering or architecture, but
was trained as a physician. In the 1820s he had studied medicine at the College of Surgeons
in Edinburgh, which was followed by a career as a lecturer of practical chemistry. For four years
worked as a university lecturer under Thomas Charles Hope, Professor of Chemistry at the College. ⁹
Unsuccessful in securing a permanent academic post, in 1833 Reid established a private chemistry
laboratory with facilities for the teaching of practical chemistry and experimental research. The latter
looking at ventilation from a largely physiological and chemical perspective. In the context of which
conducted scientific inquiries into of issue of ventilation

he was employed to work with Barry his involvement in architectural projects had been limited
to the design of the ventilation and fumes extract system for a teaching laboratory and the
remodeling of the ventilation inside the Temporary Houses of Parliament.

⁹ Reid H 1863, 5-16.
The laboratory facilities were designed by Reid, incorporated a stack-driven ventilation and fume extraction system laboratory Reid undertook various studies on ventilation taking a largely physiological perspective.

When parliament approached Reid for the first time his reputation as an authority in the field of ventilation was based entirely on the success of the system inside his laboratory. Its potential in providing a precedent for the ventilation of parliamentary debating chambers was recognised by several MPs and Lords. Lord Brougham and Earl Grey had met Reid and saw a demonstration of his system during a visit organised by the British Associated for the Advancement of Science in 1834.\(^1\) In 1835 Lord Sudeley, who was also aware of Reid’s system, was called to Westminster to advise a parliamentary committee on possible solutions for ventilating debating chambers. His proposal, which followed the same principle as the system inside his laboratory. Laboratory demonstrates. Before Reid was formally employed as the ventilator for the Palace of Westminster, he had also been involved in some preliminary inquiries for five years. These inquires enabled Reid to demonstrate to parliament how the principle could be successfully ventilation a crowded debating chamber. This reinforce his reputation as an expert of ventilation, which ultimately led the government to appoint Reid for the design of the ventilation, despite Barry’s reservations.

In October 1839, when the appointment of ventilator was discussed, Barry had voiced concerns about employing a medical doctor for the design of the ventilation system. He warned the Department of Woods and Forests that Reid did not have the required skills as he was not an engineer. Whilst acknowledging the success of his system inside the Temporary House of Commons, he felt that he was not sufficiently ‘acquainted with the practical details of the building and machinery’.\(^2\) Instead he recommend Charles Manby, a Member of the Institution of Civil Engineers who had worked on the hot water system in the British Museum, as more suitable candidate.

**PRELIMINARY INVESTIGATIONS**
The original architectural designs for the Palace, produced by the architects Charles Barry and Augustus Welby Northmore Pugin in 1835, were developed without Reid’s involvement. He was not formally employed to work on the Palace until April 1840. The architectural scheme had been procured through an architectural competition in which questions of ventilation were more marginal concerns. The competition was publicly announced in June 1835, but in the following month the House of Commons appointed a Select Committee to undertake a separate inquiry into possible ventilation solutions without reference to any specific architectural design. Reid, who was one of several experts that were consulted throughout August 1835, proposed a scheme modelled on a stack-driven system that he had designed for the Roxburgh Laboratory, his private teaching laboratory in Edinburgh. In a series of sketches he outlined the proposal for a debating chamber that was completed sealed and in which the air was supplied through a tall inlet shaft and exhausted by means of a second tower, referred to as ‘up-cast shaft’. The pull produced by warm air ascending the up-cast shaft was intended to sustain the air circulation without fans. A furnace was proposed at the base of the shaft to enhance the convection. In its final report, published in September 1835, the Select Committee was reluctant to recommend any specific ventilation scheme for the New Palace of Westminster. Nonetheless it advised to undertake tests of Reid’s proposal, providing empirical evidence of its viability. These began in spring 1836 with the erection of a model of the debating chamber in Edinburgh and were continued inside Temporary Houses of Commons, 1836-51, and the Temporary Houses of Lords, 1838-47. The Temporary Houses of Parliament enabled Reid to test and refine his concept under real-life conditions over several years. The possibility of applying the stack system to the actual Palace of Westminster, however, was not seriously considered until October 1839, when Barry engaged

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11 GB. Parliament. 1836a; Oral statement given by Tracey, C H, (10 March 1836 HC 245 Ev 6 Q59-60)
12 Yorkshire Gazette, 13 June 1835, ‘New House of Commons’, 4
13 GB. Parliament. 1835
14 Schoenefeldt, H 2014, 178-9
15 GB. Parliament. 1835; Reid, D B 1837a
16 Reid, D B 1844, 270-310.
Reid in a first feasibility study.\textsuperscript{17} For a period of four years the Barry had continued to develop his plans without reference to the principles that Reid were testing.\textsuperscript{18} Up to this point the plans had adhered to a simpler, less technical approach, involving the use of openable windows for cross-ventilation and heating by means of fireplaces. Reid’s scheme, developed between 1840 and 1846, followed a fundamental different approach that could only be implemented through significant revisions to the original architectural plans, requiring Reid to collaborate closely with Barry’s team. The original drawings and sketches show that the plans underwent changes in cross-section and plan to accommodate large network of air chamber and passages for the movement and treatment of air. This process involved extensive, at times difficult negotiations, between Barry and Reid over access to space for ventilation. These tensions culminated in several disputes in 1844 and 1845 that ultimately led to Reid’s plan being abandoned after six years of development. The quarrels between Reid and Barry have been extensively discussed by architectural historians.\textsuperscript{19} Various scholars have highlighted that Reid’s ability to successfully collaborate with architects and engineers was compromised by his inexperience with architectural projects and his limited technical knowledge and skills. This emphasis on the shortcoming of Reid’s involvement, however, has detracted attention from the significant influence that his scientific and medical background had on the design of the ventilation system or the empirical working methods that were used in its development.\textsuperscript{20} He provided skills and perspectives that were distinct from those of civil engineers and architects. His perspective on architecture was characterized through a focus on environmental issues, human physiology, and a scientific approach to ventilation exploiting the natural movement of air. In The Architecture of the Well-Tempered Environment Reyner Banham wrote that medical doctors were instrumental in establishing early practices of building science,\textsuperscript{21} and the Palace of Westminster could be interpreted as an attempt to

\textsuperscript{17}Barry C, Letter to Reid, 22 October 1839, PRO: Work 11/12, 15; Reid DB, Letter to Lord Duncannon, undated, PRO: Work 11/12, 17; Reid DB, Letter to Department of Woods and Forests, 7 November 1839, PRO: Work 11/12, 19; Reid DB, Letter to Department of Woods and Forests, 1 December 1839, Work 11/12, 24.
\textsuperscript{18}Oral statement given by Vivian G (10 March 1835 HC 66 Ev 10 Q 84-98, 131)
\textsuperscript{20}Reid, H 1863
\textsuperscript{21}Banham R 1984, 29-43
integrate doctors into a larger cross-disciplinary design team. The letters and drawings used in the communication between Reid and Barry show that Reid’s main contribution was through the development of design concepts, underpinned by experimental inquiries inside the Temporary Houses of Parliament. These enabled Reid to evaluate and refine idea, utilizing research methods that he had deployed in early laboratory-experiments in Edinburgh. Reid provided written specification, sketches and schematic drawings to outline his concepts, but he relied on the technical skills of staff in Barry’s office to develop his ideas on a technical level. This included the drafting of detailed construction drawings. In terms of his skills and knowledge Reid therefore has a closer resemblance to a modern building scientist than a services engineer with a mechanical engineering background. [Figure 1]

REID’S FIRST SCHEME FOR THE PALACE OF WESTMINSTER 1840-46

Although Reid’s early scheme was not realized, archival records provide significant insights into his original intentions. These records comprise original drawings and sketches as well as an extensive body of written evidence, comprising letters, reports and transcripts of interviews with several Select Committees between 1841 and 1846. The written communication between Reid, Barry and the Department of Woods and Forests show that the ventilation scheme was conceived as a means to protecting Parliament from the hazards of smoke pollution, which, alongside sanitation, was a prevalent environmental health issue in the nineteenth-century city. Referring to observational studies on air pollution conducted in Westminster over the previous five years, Reid argued that natural ventilation through openable windows was unfeasible due to the severity of atmospheric pollution. Instead he proposed a hermetically sealed debating chamber that was integrated into a central ventilation system servicing the entire Palace. [Figure 2] The air was supplied centrally through a network of fresh air mains inside the basement and extracted through channels at roof level. These terminated inside a

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22 Mumfort L 1938
23 Reid DB, Letter to Viscount Duncannon, 7 July 1840, PRO: Work 11/12, 34
Reid DB, Letter to Department of Woods and Forests, 28 April 1841, PRO: Work 11/12, 45
24 Oral statement given by Reid (15 August 1843, HC 583 Ev 188-96 Q2098-2340)
large shaft added above the vaulted ceiling of the Central Lobby. Fresh air for the central supply was introduced through three corner turrets in the Victoria Tower and one large shaft in the Clock Tower.\textsuperscript{25} \textbf{[Figure 3a]}

The purpose of the tall inlet shafts was to gain access to the atmosphere at a higher altitude, which Reid claimed to be less polluted than at ground level.\textsuperscript{26} During an interview, given to the Select Committee on Smoke Prevention on 19 July 1843, Reid reported that the use of ground level inlets in the Temporary Houses of Parliament had caused difficulties with protecting the internal atmosphere from smoke pollution. On several occasion, he reported, MPs got sick when the atmosphere around the inlets was overly exposed.\textsuperscript{27} The supply air had to be thoroughly filtered using canvas filters and water sprinklers.\textsuperscript{28} As pollution levels varied locally depending on the wind direction, the Houses were also equipped with two separate inlets, one facing Cotton Garden, another Westminster Abbey, which could be swapped whenever the pollution around one inlet got too severe.\textsuperscript{29} As pollution levels at the top of each towers also varied depending on the wind direction, Reid intended to adopt a similar for the Palace’s fresh air supply. The supply was intended to rely on only one tower at time. For this purpose the Clock and Victoria Tower were linked at basement level through a ‘central air chamber,’ which was equipped with valves to switch inlets depending on the state of the atmosphere at opposite ends of the site.\textsuperscript{30} \textbf{[Figure 3a]} This level of attention to issues of air pollution was the reflection of Reid’s wider engagement in issues of public health. Whilst working in Westminster he also contributed to studies of air pollution in major industrial cities and its health implications.\textsuperscript{31} Between 1844 and 1845 he was member of the Commissioners for inquiring into the state of large towns and populous districts undertaking large surveys of industrial

\textsuperscript{25}GB, Parliament, 1852a; Oral Statement given by Reid, (26 July 1842 HC 536 Ev 9 Q29-30)
\textsuperscript{26}Reid DB 1844, 199.
\textsuperscript{27}Oral statement given by Reid, (23 February 1846 HL 719 Ev 14 Q74-5)
\textsuperscript{28}Oral statement given by Reid (19 July 1843 HC 583 Ev 28 Q. 321)
\textsuperscript{29}Oral statement given by Reid (1 October 1841 HC 2-51 Ev 33 Q 315-16); Reid D B 1844, 274-6; Oral statement given by Reid, (23 February 1846 HL 719 Ev 14 Q74-5
\textsuperscript{30}Oral statement given by Reid (30 September 1841 HC 2-51 Ev 22 Q 157.
\textsuperscript{31}Reid, D B 1844, 204
towns,\textsuperscript{32} and in 1843 he advised the Select Committee on Smoke Prevention on strategies for reducing atmospheric pollution.\textsuperscript{33} His suggestions included measures addressing the root causes of pollution, such as the use of fuel efficient technologies and cleaner fuels, and solutions addressing the symptoms, for example, air filtration and the displacement of pollution through large chimneys.

The fresh air entering the Central Chamber was distributed throughout internally a network of ‘air mains’ with the assistance of steam-powered fans.\textsuperscript{34} [Figure 3a - 4] The Chamber was linked to four principal mains, two at basement level, which led towards St. Stephen’s in the west and the River Front in the east, and another two mains on the ground floor serving the debating chambers. [Figure 5] The fresh air for the House of Commons left the Central Chamber through a large circular valve on the north side, which measured 12 feet in diameter. Behind this valve was a large horizontal flue taking the air into the ‘heating chamber’ below the Commons Lobby.\textsuperscript{35} [Figure 6] Passing through another set of circular valves at the north side of the heating chamber the conditioned air entered the ‘equalizing chamber’ below the floor of the debating chamber.\textsuperscript{36} The equalizing chamber was provided for adjusting the temperature and humidity before the air was admitted into the debating chamber through openings in the floor, gallery and ceiling.\textsuperscript{37}

This arrangement followed the principle of a warm air central heating system, which was already a well-established technology by the 1830s,\textsuperscript{38} but Reid’s objective was to implement a form air-conditioning that had been tested at a smaller scale inside the Temporary House of

\textsuperscript{32} GB. Parliament. 1844; Reid DB 1845
\textsuperscript{33} Oral statement given by Reid (15 August 1843, HC 583 Ev 188-96 Q2098-2340)
\textsuperscript{34} D. B Reid, Sketches enclosed in letter to Lord Morpeth, 14 December 1846, PRO: Work 29/300; Ground floor of Central Chamber, 27 March 1843, PRO:Work 29/101
\textsuperscript{35} Plans and sections of south west corner of House, showing provision for ventilation, 19 March 1843, PRO:Work 29/2856
\textsuperscript{36} Reid D B, Plan and elevation of wall under gallery at south end of House under principal floor line, showing provision for ventilation, 4 March 1844, PRO:Work 29/2863
\textsuperscript{37} Oral Statement given by Reid, (26 July 1842 HC 536 Ev 10 Q44-5); Reid D B, Longitudinal section of House of Commons and adjoining parts, showing ventilation, 11 October 1845, PRO:Work 29/2891
\textsuperscript{38} Bruegmann R 1978 'Central Heating and Forced Ventilation: Origins and Effects on Architectural Design', JSAH, 37 143-160
Commons. This system combined warm air central heating with facilities for cooling and humidity control.\(^{39}\) Neil Sturrock and Peter Lawson (2006) argue that it was one of earliest demonstration of the principle of air-conditioning.\(^{40}\) In contrast to modern air-conditioning, which was invented by Willis Carrier in the early twentieth century,\(^{41}\) it relied on the use of passive, non-mechanical methods of cooling. According to an interview with the Select Committee on Ventilation of the New Houses of Parliament on 30 September 1841 the plan was to exploit the natural capacity of stone to absorb heat by exposing the supply air to the masonry of the vaults and paved floors inside the basement.\(^{42}\) He argued that it provided an economical method of cooling at a large scale. Cooling methods involve passing air through nets filled with ice, which was trialled inside the Temporary Houses, was not viable due to the cost and limited availability of natural ice.\(^{43}\) The arrows shown on a cross-section of the House of Commons, dated 11 October 1845\(^{44}\) indicate that cool air could be admitted directly from the basement into the equalizing chamber using vertical 'ascending shafts' at south and north end of the House. Equipped with adjustable valves these shafts allowed to by-pass the heating chamber or to mix cool and warm air.

**HARNESSING NATURAL PRINCIPLES**

The vitiated air of the House of Commons was extracted through the Central Tower, which acted as the central up-cast shaft for the whole Palace. In contrast to the Victoria and Clock Tower, this Central Tower had not been part of Barry's original architectural plans. It was added retrospectively and as the cost for the tower was not covered by the original budget approved by the Treasury in 1836, his scheme underwent extensive review. In several oral

\(^{39}\) **Note:** For detailed study of the earlier air conditioning methods used in the Temporary Houses of Parliament see: Schoenefeldt H 2014

\(^{40}\) Sturrock N and Lawson-Smith P 2006

\(^{41}\) Ackerman M 2010

\(^{42}\) Reid, D B 1856, 159; Oral statement given by Reid (30 September 1841 HC 2-S1 Ev 22 Q 157

\(^{43}\) In the early and mid-nineteenth century ice was not produced artificially and the early Victorians relied on supply of natural ice, which was harvested in winter and stored inside icehouses for use over the summer months. (Hiles T 1893, B-11) Ice began to be imported from US in the 1840s but it remained an expensive good until the late 19th century. Weightman G 2003; Kistler L, Carter C and Hinchey B 1984

\(^{44}\) Reid D B, Longitudinal section of House of Commons and adjoining parts, showing ventilation, 11 October 1845, PRO:Work 29/2891
statements given in front of the Select Committee on Ventilation between 1841 and 1842 Reid argued that the tower had two important functions. The first was to protecting the atmosphere around the Palace from its own emission by discharging the smoke of its several hundred fireplaces at a high altitude. His second objective was to eliminate the high running costs of mechanical operated systems by harnessing of natural convection and wind pressure. The use of fires or fans was to be limited to periods when adequate ventilation could not be sustained through the ‘natural impulse of the air as introduced by currents of wind, and the natural tendency of hot and vitiated atmosphere to escape’ He claimed that its effectiveness relied on the height of shaft and between 1841 and 1843 proposed towers ranging between 150 and 250 feet in height. These were also moved to an elevated position above the roof so that hot air could rise more naturally into the shaft. The buoyancy within the shaft was to be maintained by exploiting body warmth and waste heat from smoke (fire places and boilers), gas fumes (lighting) or kitchens. Ventilating fires were only to be deployed temporarily to boost the ventilation, typically when the House gets crowded or during summer, when the quantity of waste heat was limited. To convey the vitiated air and fumes of several hundred rooms into the Central Tower Reid planned an extensive network of large flues, which were situated below the roof.

The original cross-section and plans illustrate how the House of Commons was intended be integrated into this system. The hot air from the debating chamber and Division Lobbies was collected inside the ‘vitiated air chamber’ above the ceiling, which was connected to the bottom of the Central Tower through a horizontal air channel. [Figure 6 and 7] The smoke

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45 GB. Parliament. 1841; GB. Parliament. 1842
46 Reid, D B 1856, 159; Oral statement given by Reid (24 September 1841 HC 2-51 Ev 8-10 Q7-13)
47 Oral statement given by Barry (14 August 1846 HL 719 Ev 7-8 Q17; D. B Reid, Tracing of a sketch plan made in Dr Reid’s Office showing ventilation shaft in central tower, 15 June 1847, PRO:Work 29/3049;Reid DB, Section through Central Tower showing various ventilating designs, 15 June 1847, PRO:Work 29/3052
48 Oral Statement given by Reid, (26 July 1842 HC 536 Ev 11 Q56)
49 Oral Statement given by Reid, (26 July 1842 HC 536 Ev 14 and 6 Q4 and 83)
50 Oral statement given by Reid (24 September 1841 HC 2-51 Ev 10 Q17)
51 The term ‘vitiated air’ was used in the nineteenth-century to describe room air deteriorated due to human respiration (Carter J 1981)
channels were located on the floor above the vitiated air chamber. Conscious that the pull of the Central Tower would not be sufficient to ventilate several hundred rooms simultaneously, he introduced valves that permitted individual spaces, including the debating chambers, to be switched to the shaft whenever they were occupied.52

This shows that Reid’s proposal was based on a highly developed understanding of the capabilities as well as the limitations of natural ventilation utilizing convection or wind pressure, which Reid also described in several text books.53 In Rudiments of Chemistry: with illustrations of the chemical phenomena of daily life (1836) and Elements of Practical Chemistry (1830) Reid introduces the science behind the natural movement of air induced by atmospheric pressure, gravity or thermal buoyancy. He also demonstrate how it can be studied experimentally in the laboratory or exploited in buildings to drive ventilation.54 The application of such natural principles was also not limited to the design of the up-cast shaft. Reid also spoke of the possibility of limiting the use of fan-driven supplies by exploiting the wind, whenever it was available, to deliver fresh air into the basement.55 As such it has close resemblance to the ‘mixed-mode’ approach used in modern sustainable buildings, such as the Weber Centre at Judson College, Chicago,56 where mechanical services are utilized to complement, not to replace, natural principles. This reinforces Vida Lerum’s argument that the nineteenth century architecture could provide potential lessons for sustainable environmental design in the twenty first century.57

THE CHALLENGE OF ACCOMPLISHING A COMFORTABLE DEBATING CHAMBER.

52 Reid DB, Statement explanatory of the arrangements for warming and ventilating the new House of Commons, 5 April 1852, in (HC 1852 402 Ev 545-48)
53 Reid D B 1844, 83-86.
54 Reid, D B 1830; Reid, D B 1836, 184-85.
55 Reid, D B 1856, 159; Oral statement given by Reid (30 September 1841 HC 2-51 Ev 22 Q156
56 Lomas K, Cook M and Short C 2009
57 Lerum V 2016
The proposal for an air-conditioned debating chamber described in the previous section formed part of a more complex system of climatic control that Reid had developed to enhance thermal comfort. It was the culmination of detailed studies of Member’s perception of indoor climates and air quality inside the two temporary chambers. These studies, which utilizing research methods that Reid had in early laboratory experiments in Edinburgh, illuminate most clearly how Reid's medical background had shaped the perspective and working methods underlying the design of the ventilation system. Detailed accounts of these early experiments were published in two books, Illustrations of the theory and practice of ventilation (1844) and Ventilation in American Dwellings (1858), and in several lectures.58 One series of these experiments examined the physiological effect of air purity and climates. In these studies volunteers, after having been exposed to different climatic conditions and atmospheres of varying air quality, were interviewed about how these affected their concentration, appetite or physical well-being.59 Similar methods were also used to empirically evaluate and refine technical solutions. In the lectures Progress of Architecture (1856) and The Revision of Architecture in Connection with the Useful Arts (1855) Reid reported of experimental rooms that he had erected to study ways of diffusing air currents, using different configuration of perforated walls, floors or ceilings.60 Volunteers were placed inside these rooms to provide feedback on the thermal sensations produced by the incoming air currents and how these were affected by velocity, temperature or humidity. A similar approach was used in the model of the debating chamber to examine how the higher ventilation rates, which are required to maintain good air quality standards under crowded conditions, could be achieved without causing uncomfortable draughts.61 As before it was evaluated based on the self-reported experience of volunteers.62 It demonstrated that higher ventilation rates were achievable if the

58 Reid, D B 1844, 176-81, 334-35; Reid, D B and Harris, E 1858, xix-xxiv
59 Reid, D B 1837b
60 Builder, 5 May 1855, ‘The revision of architecture in connection with the useful arts’, 208-9; Reid, D B 1856, Eight lectures by David Boswell Reid on Progress of architecture in relation to ventilation, warming, lighting, fire-proofing, acoustics, and the general preservation of health’, Smithsonian Annual Reports, 147-196.
61 Reid, D B 1837a; GB. Parliament 1835
62 Letter from Doctor Reid to Lord Duncannon, on Ventilation of House of Commons, 28 March 1838, (HC 1837-38 277); Caledonian Mercury, 28 July 1836, ‘Philosophical Society,’ 3
system was switched from an upward supply through the perforated floor to a downward supply from the ceiling.

Tests were continued inside the two debating chamber of the Temporary Houses of Parliament but this time under real-life conditions and involving MPs and Lords instead of volunteers. In the Temporary House of Commons, where Reid was unable to implement a switchable supply, the air was continually supplied upward through a perforated floor. According to interviews with MPs, this resulted in problems with cold feet and legs, which became particular severe during crowded debates, when the ventilation rate was boosted to prevent overheating and maintain a fresh atmosphere. In his scheme for the Permanent House of Commons and Lords Reid proposed to address this issue by returning to more complex arrangements that permitted air to be supplied and extracted at floor and ceiling level. Sketches produced between January and October 1845 outline proposals for the ceiling of the House of Lords. These show a chamber for the extraction of vitiated air above the central row of ceiling panels, which was connected to the Central Tower. Fresh air, which was supplied from the basement through vertical shaft, was introduced through the side panels.

In the Temporary Houses of Commons MPs were actively involved in evaluating the artificial climate inside the debating chamber and by illuminating difficulties with achieving satisfying conditions their feedback was informing Reid’s effort to refine his system. In order to gain

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63 Oral Statement given by Reid (6 August 1844 HL 629 Ev 68 Q557)
64 Oral statement given by Reid, (14 August 1846 HL 719 Ev 47 Q36)
65 Reid D B, Plans and section of ventilating system of House of Lords to form basis of the proposed arrangement for House of Commons, 5 April 1847, PRO: Work 29/3035; Reid D B, House of Lords: plan and section of air chambers over ceiling, 10 July 1846, PRO: Work 29/2896; Reid D B, House of Lords: plan above the ceiling showing provision for ventilation, 1845, PRO: Work 29/2888
66 Reid D B, House of Commons plan and section showing ventilation at north end, 11 October 1845, PRO: Work 29/2892
67 Reid D B, Plan and sections of ceiling showing arrangement of chambers for ventilation, 16 July 1845, PRO: Work 29/2897; Reid D B, Section through Royal Gallery looking south showing ventilation flues, 1845, PRO: Work 29/2883; Reid D B, Plan of principal floor, 1845, PRO: Work 29/2894.
68 Reid H 1863, 16-8
69 This process of technical refinement is discussed in detail in: Schoenefeldt 2014, 175-215
tighter control over different climatic factors affecting thermal comfort, it evolved into a more complex system that incorporated a form of air-conditioning and sophisticated methods of environmental monitoring. The latter combined the recording with physical measurements with the collection of subjective feedback from MPs. The attendants working the ventilation continually engage with MPs, acquiring an intimate understanding of the Members’ response to various environmental stimuli. Being a psychological state, thermal comfort was not directly measurable through scientific instruments, but required qualitative methods. Reid noted that it allowed gathering 'information as to the ever-changing feelings of Members, of which no one can possibly judge but themselves'. In his book Illustrations of the Theory and Practice of Ventilation Reid highlighted that thermal comfort was not only affected by environmental but also personal factors, such as clothing, health conditions or level of physical activity.

Demonstrating a methodology by which the perceived reality could be continually 'metered' alongside the measuring of physical stimuli, this monitoring system could be considered an early example of psychophysical principles being applied to architecture. Reid’s perspective resembles very closely what the German scientist Gustav Fechner described as äussere psychophysik (outer psychophysics). In Elemente der Psychophysik, published in 1860, Fechner described outer psychophysics as a scientific field concerned with the correlation between physical stimuli (äusserer reiz) within the environment and the sensations (innere empfindung) they produce. Although his approach was less systematic than Fechner’s later method, Reid reviewed self-reported experience to determine how people’s perception of thermal comfort was affected by climatic conditions. Analysing several years of user-responses and measured data collected inside the Temporary Houses of Commons he attempted to determine the conditions at which the majority of MPs felt comfortable. Reid wrote that 'as far as I have been able to observe, a temperature of 65F, with an atmosphere

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70 Oral Statement given by Reid (17 June 1844, HC 448 Ev 27 Q321
71 Reid, D B 1844, 168-73.
72 Fechner G 1860
moving in a very gentle stream, so as not to be perceptible, is the most agreeable in rooms that are not overcrowded.’ Referring to humidity he reported that ‘when there is a difference between 5F between the dry thermometer and wet-bulb thermometer next to it, I have the least number of complaints’.73

Managing a climate based on experience was a difficult process due to conflicting feedback from different Members. Reid reported that there was ‘scarcely a meeting of the House at which there are not some Members who would like the temperature to be at 55F degrees, and others at 70F or 72F’.74 It required the Sergeant-at-Arms Sir William Gosset to moderate the responses of individual Members. In 1839 Gosset wrote:

‘…sometimes Members come to me, and say the House is very hot, or very cold; I look at the thermometer, and see if so, for different people have different feelings with regard to temperature. People come in very hot, and say, “How cold the House strikes;” and another man says “I have been sitting here half an hour, and I am in fever;” and if I see the thermometers are too high or too low, I give directions accordingly’75

Starting in 1838 Reid used the Temporary House of Lords to test an alternative approach to climate control. He explored how far thermal comfort could be improved if the interior was divided into different climate zones instead of being uniform.76 Crowded areas, being more likely to experience overheating, were supplied with cooler air than more sparsely populated areas. The temperature in one section could be as low as 52°F and as high as 75°F in another. In the House of Commons, Reid and the Sergeant-at-Arms reported that it was difficult to achieve a consensus among MPs when the climate was uniform, making climate control a

73 Oral statement given by Reid (26 March 1852, HC 402 Ev 47-82 Q331-530)
74 Oral statement given by Reid (29 March 1852, HC 402 Ev 99-100 Q642)
75 Oral Statement given by William Gosset (24 June 1839 HC 501 Ev 39-51 Q693-742)
76 Oral Statement given by Reid (17 June 1844, HC 448 Ev 27-28 Q317-23)
political struggle. Continuous attempts were made to manage the shared climate according to the preference of the majority, whilst dealing with few individuals who were vocal about their dissatisfaction. Reid noted that

'our only alternative has frequently been to make a local change under the benches occupied by them [certain individuals] or suit their convenience at the expense of incommoding the House generally, unless they were left subject to an amount of annoyance of which they bitterly complained, for the state of the air being more congenial to those around them than to themselves'

Eyewitness accounts given by the Lords between 1838 and 1846 suggest that the new approach had not been successful in achieving a more comfortable environment. Lord Campbell wrote in September 1843 that whilst the air quality had improved, the Lords suffered from a lack of control over temperatures and currents. During a debate in February 1843 he complained that the 'alternate heat and cold of the place made it at one time a cold bath, and at another a vapour bath'. In June 1845 Lord Brougham and the Marquess of Clanricarde complained about the 'wretched state' of the atmosphere and Campbell noted that some Peers 'suffered so severely last night from the imperfect ventilation, and the sudden draughts of hot and cold air.' On 24 April 1846 Brougham described the chamber as 'sometimes broiling and sometimes freezing', and Campbell noted in May that 'nothing could be more detestable than the result of the learned Doctor's experiments in their Lordships' House.'

Despite the wide disapproval, Reid followed the same concept in his plans for the Permanent Houses of Lords and Commons. Reid argued that the technical arrangements had been

77 Oral Statement given by Reid (17 June 1844, HC 448 Ev 27-35 Q320- 387)
79 Hansard HL Deb. vol 66 cols. 1033-6, 21 February 1843
80 Hansard HL Deb. vol 81 cols. 120-2, 5 June 1845
81 Hansard HL Deb. vol 85 cols 970-6, 24 April 1846
82 Hansard HL Deb 26 June 1846 vol 87 cc1033-5
constrained by funding, but the main issues was insufficient cooperation, with the Lords not providing the regular feedback required to implement the idea of a responsive system.\textsuperscript{83}

In several interviews Reid described how he intended to apply the concept to the Permanent House of Lords. The interior was to be divided into five climatic zones, located around the ministerial and opposition benches, throne, bar, and within the central floor. In each zone the climate and air supply was to be regulate according to the number of Lords present, but in addition each bench was equipped with a separate supply to achieve a greater level of local control.\textsuperscript{84} These supplies were only to be activated by the attendants on request, and individual control was to be limited to Lords who had to sit inside the chamber for extended periods. Reid’s objective was to give 'all who are tied down to official seats a ventilation in unison with their own feelings to a certain extent, while the general ventilation is arranged for the House'.\textsuperscript{85} The satirical magazine Punch likened Reid’s system to a brewery, offering Members ‘draughts of different kinds of atmosphere’.\textsuperscript{86} [Figure 10]

THE HOUSE OF COMMONS BECOMES AN INDEPENDENT SYSTEM

The correspondence show that efforts to apply Reid’s ventilation scheme to the Palace were undermined by difficulties with achieving a successful collaborations between Reid and Barry. Between 1844 and 1845 Reid and Barry had several disputes, including quarrels about the cross-section of the Central Tower,\textsuperscript{87} the use of roof spaces for conveying air and smoke to the Central Tower\textsuperscript{88} and potential fire risks.\textsuperscript{89} Despite several attempts by the Department of Woods and Forests to moderate the negotiations, these difficulties remained unresolved and

\textsuperscript{83} Reid D B 1844, 292-3; Oral Statement given by Reid (17 June 1844, HC 448 Ev 27-35 Q320- 387);
\textsuperscript{84} Oral Statement by Reid (6 August 1844 HL 629 Ev 65-69 Q535-63)
\textsuperscript{85} Oral statement by Reid, (19 March 1846 HC 574 Ev 90 Q985)
\textsuperscript{86} Punch, 18 April 1846, ‘Reid's Air Brewery’, 168; Punch, 16 May 1846, ‘Reid’s Process’, 218
\textsuperscript{87} Oral Statement given by Reid (14 August 1846, HL 719 Ev 42 Q22)
\textsuperscript{88} Reid DB, Letter to Commissioners of Woods, 10 February 1845, PRO:Work 11/12, 147; Reid DB, Letter to Barry C, 9 May 1845, PRO:Work 11/12, 139-40; Barry C, Letter to Reid DB, 10 May 1845, Work 11/12, 140-41
\textsuperscript{89} Barry C, Letter to Reid, 15 April 1845, PRO:Work 11/12, 124; Barry C, Letter to Reid, 7 May 1845, PRO:Work 11/12, 138; Reid DB, Letter to Barry C, 7 May 1845, PRO:Work 11/12, unnumbered; Reid DB, Letter to Barry C, 12 May 1845, PRO:Work11/12, 141; Reid DB, Letter to Commissioners of Woods, 12 May 1845, PRO:Work 11/12, 142; Reid DB, Letter to Commissioners of Woods, 20 May 1845, PRO:Work11/12, 152
Reid’s scheme was finally abandoned in autumn 1846, following a parliamentary inquiry. Having caused delays and rising costs, several reviews of the impact of Reid’s involvement were undertaken between 1845 and 1846. It involved two Select Committees, appointed by the House of Lords and Commons respectively, and an independent review of Reid’s working methods by the architect Joseph Gwilt. The Committee interviewed Barry, Reid and Alexander Milne, First Commissioners of Woods and Forests, about the process, which illustrated that Reid’s ability to collaborate with the architects and his engineers was compromised by insufficient drafting skills and experience with architectural design as a process. Whilst he had deep knowledge of general scientific principles, his experience with translating these principles into technical solutions or incorporating into architectural plans, was limited. Goldsworthy Gurney, a physician and expert in the ventilation of mines and sewers, also questioned the technical feasibility of Reid’s scheme. He challenged it in a petition read at both Houses in April 1846. Claiming that the Palace was too large to be ventilated by a single chimney, he proposed to replace with a system of local shafts. The Department of Woods appointed three referees, the engineer George Stephenson, the architect Phillip Hardwick and the chemist Thomas Graham, to review these claims. They approved his critique, arguing that the centralized scheme, if applied to the entire Palace, would become overwhelmingly complex and that it could be simplified by using a series of smaller up-cast shafts. Barry also offered the Lords Committee to take on the responsibility for ventilating the House of Lords and guaranteed that it could be completed in 1847 if it was done without Reid’s interference. The Committee accepted his proposal in August 1846, arguing that further delays in the completion in the House could be prevented if Barry’s office was given full control over all aspects of the design.

90 GB. Parliament. 1846a; GB. Parliament. 1846c-f
91 Oral statement given by Barry (23 February 1846, HL 719 Ev 8 Q21)
92 Times, May 26, 1846, ‘House Of Commons’, 5
93 Hansard HL Deb. vol 85 cols. 114228, April 1846; Hansard HC Deb. vol 85 cols 788, 21 April 1846
94 Oral statement given by Goldsworthy Gurney (11 May 1846 HL 719 Ev 24-30 Q4-51).
95 Oral statement given by Goldsworthy Gurney (11 May 1846 HL 719 Ev 31 Q54).
96 GB. Parliament. 1846b
97 GB. Parliament. 1846a, 41
REID’S FINAL DESIGN FOR THE HOUSE OF COMMONS, 1847-52.

Reid’s masterplan was abandoned in September 1846 and the ventilation was reorganized following the referees’ proposal for a decentralized strategy. Reid’s responsibility was confined to the House of Commons, a decision that Reid challenged by undertaking several unsuccessful attempts to get Parliament to review the decision. His new territory extended from the north end of the Central Hall to the corridor behind the Speaker’s chair and included the Commons Lobby and Division Corridors. The ventilation in other parts of the Palace, including the House of Lords, came under Barry’s control. Assisted by his engineers Alfred Meeson and William Jeakes, and involving Michael Faraday as technical advisor, Barry developed a new system. The concept of a central up-cast shaft was abandoned and replaced by several local shafts, which had the external appearance of gothic spires. Added gradually between 1847 and 1855, these shafts resulted in a significant architectural transformation of the roof-scape.

On 5 April 1847 he send a set of over 40 drawings to Office of Woods, outlining a new scheme for the House of Commons that still adhered to his earlier concepts. Some features that were already completed according to his original plans were re-utilised. These included the equalizing chamber, supply ducts for the East and West Galleries and the four large shafts supplying the galleries at the north end. Other features, including the air supply had to be remodeled as the House was no longer integrated into the Palace’s central supply and discharge system. It had to work as an independent system. The ventilation at ceiling and floor

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98 A detailed exploration of these negotiations can be found in Schoenefeldt, H. 2016a.
99 Reid DB, Petition to the House of Commons, 23 February 1849, PRO: Work 11/16, 14
100 Oral statement given by Reid (25 March 1852 HC 402 Ev 22 Q168-72)
101 Builder, 21 February 1852; Builder, 13 March 1852
102 Barry C, Report as to the present stage of the works, 3 January (1845 HC 1845 100) HMSO; Charles Barry Report as to the present stage of the works, 4 April 1845, in GB. Parliament. 1846d, 187; Barry C, Report as to the present stage of the works, 1 November 1845, in GB. Parliament. 1846d, 187.
103 Reid D B, Plan and elevation of risers in east and west wall, 19 February 1844, PRO: Work 29/2864
104 Reid D B, House of Commons plan and section showing ventilation at north end, 11 October 1845, PRO: Work 29/2892
level were designed as separate systems, each equipped with its own set of fresh air inlets, up-cast shafts and climatic control arrangements. [Figure 12]

THE CEILING SYSTEM

Reid new design was implemented between May 1847 and February 1852 but the plans underwent several modifications. The design of important features, such as the air supply for the ceiling inlets, were the outcome of intense negotiations, involving Reid, Barry and several committees. Although his involvement had been restricted to the House of Commons, Reid still required Barry’s approval for critical features of his system. Problems with disagreements disrupting design decisions continued and in 1848 the Office of Woods appointed a commission to supervise the communication between Barry and Reid.105

In spring 1847 Barry reduced the height of the Central Tower.106 He argued that the great height of former designs for the Central Tower was no longer functionally required and also rejected them on architectural grounds.107 Barry proposed converting it into a local shaft for the Lords. Initially Reid had hoped to retain the tall tower as a fresh air inlet for the ceiling system, which could be operated independently from the floor system served by the Clock Tower.108 Having no longer access to the Central Tower, Reid introduced a new shaft on the west side of the Commons Lobby.109 In June 1848, following twelve months of intense negotiations, Reid and Barry agreed a new arrangement for the ceiling supply.110 The primary inlet was embedded inside the cast-iron roof facing the river, and was equipped with adjustable

105 Hansard HC Deb. vol 111 cols. 458-60, 30 May 1850; Commissioners of Works, Letter to Reid, 19 December 1851, PRO: Work 11/14, 672
106 Note: Barry’s original plan for the Central Tower was not never realized. It only served as a discharge for hot air from the Central Lobby and several corridors. Fresh air was supplied from the Central Chamber through the cast-iron gratings in the floor of the Lobby and escaped through the oculus in the ceiling vault.
107 Gore, C, Letter to Barry, 27 July 1841, PRO: Work 11/12, 68
108 Reid DB, Section of central tower illustrating discharge of vitiated air and one of the sources of supply of fresh air, 31 May 1847, PRO: Work 29/3051
109 Reid DB, Letter to the Commissioners of Woods, 19 July 1847, PRO: Work 29/3053; Reid DB, Drawing of auxiliary heating and ventilating apparatus in air channel between House Lobby and Central Tower, 5 April 1847, PRO: Work 29/3046
louvres.[111] When it was exposed to pollution the supply was switched to a second inlet, which was located inside a turret in the north-west corner of St. Stephen’s Porch.[112] The fresh air was conveyed to the House through passages under the roof. The ceiling supply had its own fan and heating.[113] The fan was located at the north side of the Central Tower and the air was warmed inside a passage lined with steam pipes. This passage terminated in the fresh air chamber above the central ceiling panels. It was admitted into the debating chambers through gaps between the panels and openings inside hollow ornamental beams.[114] It was adjusted manually by means of sliding valves.[115]

The vitiated air chamber, which was situated above the side panels, was connected to the new up-cast shaft. The air entered at the base of the shaft and was exhausted through cast-iron valves on the top, which could be adjusted with the aid of pulleys.[116] The pull produced by the rising hot air, which at times was enhanced with coke fire, drove the vitiated air out of the debating chamber. As it was not strong enough to ventilate the debating chamber and lobbies simultaneously valves were used to connect the shaft to individual spaces, including the Commons Lobby, the Ladies and Stranger’s Gallery.[117] During votes, for instance, the valves were switched to re-direct the pull from the House to the Division Lobbies.[118]

THE FLOOR SYSTEM

[111] Reid DB, Drawing showing modification proposed for the supply of fresh air, 7 June 1848, PRO:Work 29/3066
[112] Reid DB, Section through roof over St Stephen’s Hall showing construction and arrangement of smoke and air flues, 29 June 1848, PRO:Work 29/3067; Reid DB, Plan and section over the groins of St Stephen’s Hall and St Stephen’s Porch showing flues and air channels in roof, 27 December 1851, PRO:Work 29/2960; Oral statement given by Reid (26 March 1852, HC 402 Ev 56-62 Q373-407)
[113] Reid DB, Plan and section of roof space between House lobby and central tower, 5 April 1847, PRO:Work 29/3046; Reid DB, Details of new apparatus in air chamber in the roof over Commons’ corridor, 22 January 1850, PRO:Work 29/3083
[114] Barry C, Plan of Principal Floor, 10 January 1851, PRO:Work 29/3090; Oral Statement given by Barry (5 April 1852 HC 402 Ev 224 Q1491) Civil Engineer and Architect’s Journal, September 1852, ‘Dr. Reid’s Arrangement for Warming and Ventilating the New Houses of Commons’, 292-3
[115] These valves are shown in several drawings, such as: Reid DB, Longitudinal Section, 5 April 1847, PRO: Work 29/2905; Reid DB, Plan of roof, 5 April 1847, PRO: Work 29/3027
[116] Reid DB, Plan, elevations and sections of vitiated air shaft, 24 February 1848, PRO:Work 29/2916
Reid DB, Plans and sections showing valves at top of vitiated air shaft, 19 July 1847, PRO:Work 29/3054; Cross section through House and divisional lobbies looking south, PRO:Work 29/2994; Longitudinal section through House and Commons lobby looking west, PRO:Work 29/2993
[118] Oral Statement given by Reid (30 April 1852, HC 402 Ev 495 Q3573)
The territorial border drawn in 1846 required Reid to develop a new supply for the floor system. Barry retained parts of the centralized supply within his territory, using the Victoria as the main inlet, but it was physically separated from the House of Commons. As the House had only access to the high level inlet inside the Clock Tower, Reid adopted the Central Chamber as a new back-up for periods when the Clock Tower could not be deployed due to air pollution.119 Mirroring the principles of the roof level inlets, the use of switchable inlets was part of Reid's strategy to making the building more responsive to changing levels of air pollution. His initial plan was to use the whole Central Chamber to switch the supply between the four surrounding courts depending on pollution levels.120 [Figure 14] In July 1848, however, Barry sub-divided the chamber as he required the south side for his own system. [Figure 15 and 16] Within Barry territory the fresh air admitted through the Victoria Tower was conveyed into the southern half of the chamber, where it was tempered using a heating and humidification system before entering the supply passages leading towards the River Front, St. Stephen's Hall and House of Lords.121 As a result Reid was left with only two apertures giving access to fresh air in the Cloister Court and Common Inner Court.122

Within Reid’s territory, the air admitted through this Central Chamber or Clock Tower was conveyed to the House through basement passages and ascended through ceiling valves into the heating and cool air chambers on the ground floor.123 [Figure 17] Three rectangular valves were provided for the heating chamber, which was filled with hot-water pipes, and twelve circular valves for the cool air compartment surrounding the heating chamber.124 At the next stage the cool and heated air rose through separate valves into the equalizing chamber. The

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120 Reid DB, Plan and section of Central Chamber, 26 April 1848, PRO:Work 29/3063; Reid DB, Plans of basement and ground floor, 5 April 1847, PRO:Work 29/3007 and 3008
121 Barry C, Description of the mode of warming and ventilating the House of Lords, 2 April 1852, GB. Parliament. 1852a, 600-1; Barry C, Basement plan of central eastern portion showing warming and ventilating ducts, 20 October 1849, PRO:Work 29/2923; Barry C, Plan of central hall showing pipe runs, 5 January 1850, PRO:Work 29/2927; Barry C, Plan of basement and ground floor of Victoria Tower to central tower showing air channels, 14 October 1852, PRO:Work 29/2969.
123 Reid DB, Cross-section, 10 January 1851, PRO:Work 29/3094; Reid DB, Plans and sections of principal heating apparatus, 5 April 1847, PRO:Work 29/3026; Reid DB, Plan of equalizing chamber, 5 April 1847, PRO:Work 29/3014.
124 Reid DB, Detail of air valves, 5 April 1847, PRO: Work 29/3041-43.
temperature and relative humidity was monitored using a hygrometer and twenty thermometers.\textsuperscript{125} The air was tempered using the air-conditioning system tested in the Temporary House of Commons. The Permanent chamber had facilities for cooling, heating, humidifying and dehumidifying the supply air.\textsuperscript{126} The humidity of the supply air was raised with the aid of steam or by evaporating water, and was lowered using an 'absorbent of moisture', which Reid did not specify. Cooling was provided through passive, non-mechanical means. The supply air temperature was lowered by passing cold water through the heating pipes or, if the air was sufficiently dry, by evaporating distilled water. Ice, which was used for brief trials in the Temporary House, was not deployed. In addition to lowering the actual air temperature, Reid exploited the cooling sensation produced by air currents passing over the human skin, which lowered the perceived temperature.

In winter the supply air temperature was controlled by adjusting the temperature of the heating pipes, but a process of mixing heated and unheated air was used to lower the temperature in response to sudden changes in attendance. The valves above the heating chamber could be closed and heated air re-directed into the surrounding cool air chamber.\textsuperscript{127} When the House had to be cooled down more rapidly, the heating chamber was closed completely and cool air admitted directly from the basement.

The floor was covered with perforated cast-iron plates, but in contrast to the Temporary House of Commons, where fresh air was admitted across the entire floor, it had outlets to extracted vitiated air downwards as well as inlets to supply fresh air upwards. Inlets were confined to areas where MPs were not exposed to currents. Air was supplied through the floor between the table and bar, risers in the gangways\textsuperscript{128} and along the back of the benches. The chairs for the Speaker and Sergeant-at-Arms had individual supplies. The supplies could be adjusted

\textsuperscript{125} Oral Statement given by Reid (20 April 1852 HC 402 Ev 52-4 Q361)
\textsuperscript{126} GB. Parliament. 1852a,  545 - 48.
\textsuperscript{127} Oral statement given by Daukes S W (5 April and 6 April 1852 HC 402 Ev 258 and 270, Q1812 and Q1931
\textsuperscript{128} Oral statement given by Reid (30 April 1852 HC 402 Ev 484 Q3545)
individually by attendants inside the Equalizing Chamber, using over 60 sliding valves. [Figure 18] The inlet along the back of every bench had ducts with individual valves.\footnote{Barry C, Ceiling above equalizing chamber with supply tubes, valves and flaps, 28 June 1851, PRO: Work 29/3100; Barry C, Section through gangway and seats, 10 January 1851, PRO: Work 29/3093.} [Figure 19 and 20] Some air was continuously extracted downwards through the floor immediately in front of the benches.\footnote{Oral statement given by Reid (26 March 1852 HC 402 Ev 50-54 Q346-362); Oral statement given by Reid (17 June 1844 HC 448 Ev 27-29, 35 Q317-28, Q387)} This entered a vitiated air chamber below the floor and was discharge via the boiler chimney, which terminated in the turrets in the north-west corner of the Central Tower.\footnote{Reid DB, Plan of basement, 5 April 1847, PRO:Work 29/3007} Special provisions were made for enhancing the thermal comfort of front benchers, the Speaker and Sergeant-at-Arms by warming their feet with hot-water plate radiators that were attached to the underside of the iron floor.\footnote{Reid DB, Details of underfloor plate radiator, 22 January 1850, PRO:Work 29/3081-89} 

**ENVIRONMENTAL MONITORING**

From February 1852 till April 1854 the environmental system was systematically monitored as part of the day-to-day operational procedures. Filling a similar role to the digital sensors of modern Building Management System, the monitoring data was collected to provide the human operators with feedback on system’s performance. Feedback was acquired through the recording of measurements, direct observations, and by collecting personal responses from MPs. Reid envisaged a system was responsive to internal and external environmental conditions as well as the MPs personal experience. It followed the same principles as the monitoring regime tested inside the Temporary Houses of Commons. It involved collecting subjective feedback alongside the recording of measurements. The attendants kept log-books, which contained registers for qualitative and quantitative data. [Figure 21] It included columns for numerical data (temperature, humidity and air speed, number of MPs and written notes referring to operational procedures and air quality, which was only monitored through direct observations. It included detailed notes on how the supplies were switched in response to external air pollution. On 6 March 1854, for instance, attendants noted that the atmosphere...
was ‘very foggy and charged with smoke’ and that the supply was switched to central hall as that from the Clock Tower very smoky’. These issues continued over two weeks and attendants wrote that switching the supply made the air ‘better but not good.’ On one occasion a ‘foggy atmosphere loaded with smoke of the neighbourhood penetrated the building.’ Within the debating chamber itself only the air temperature was measured, using eight thermometers. Four thermometers were fixed to the back wall of the galleries.\(^{133}\) The other four were on the main floor, near the chairs of the Speaker and Sergeant-at-Arms and behind the benches on the opposition and government side.\(^{134}\) Inside the debating chamber the messenger of the Sergeant-at-Arms recorded temperatures at hourly intervals and collected qualitative feedback from individual MPs.\(^{135}\) Registers with the measured data was send directly to the ventilator’s office, where it was transcribed into the central log-book and analysed. The MPs self-reported experience was carefully reviewed by Sergeant-at-Arms Lord Charles Russell before order were send to the superintendent managing the attendants. Reid was the superintendent from February till November 1852, after which he was succeeded by the engineer Alfred Meeson. Russell reported that he was the ‘medium of communication, as respects the ventilation, between Dr. Reid and the Members’\(^{136}\) and also highlight that moderating the often conflicting response from individual MPs was a challenging process. References to orders and feedback can be found inside the log-books.\(^{137}\) On 13 April 1853, for instance, attendants wrote that the ‘Speaker complained of draughts round his head’. On 31 March it was noted that the Speaker felt ‘too warm’ and on 7 April the Sergeant-at-Arms ‘wished the House a little cooler.’ The level of environmental monitoring Reid had envisioned was highly ambitious and the log-books shows the attendants rarely collected enough data to fill the entire sheet. The quantity of recorded data varied significant between days. This is not surprising as the monitoring was a labor intensive procedure. Every reading was recorded

\(^{133}\) Oral statement given by Goldsworthy Gurney (26 April 1852 HC 402 Ev 403 Q3002-3.

\(^{134}\) Reid D B, Temperature at the House of Commons, taken by the messenger of the Sergeant-at-Arms, 22 March - 4 May 1852, in GB. Parliament. 1852a, 580-85.

\(^{135}\) GB. Parliament. 1852a, 545-48; Oral statement given by Reid (20 April 1852 HC 402 Ev 499-500 Q3597-8)

\(^{136}\) Oral statement given by Charles Russel, 26 March 1852 HC 402 Ev 40 Q255-56.

\(^{137}\) Registers of temperature control and ventilation for the House of Commons 1853-1854, Parliamentary Archives: OOW/5.
individually by hand without the assistance of automatic recording devices, let alone modern
digital data loggers. To gain a full set of temperatures alone attendants had to take over fifty
readings per hour, each of which had to be manually logged at different locations. Reid was
clearly aware of this issue as he proposed introducing robes and pulleys to operate dampers
remotely and speaking tubes and bells to improve communication between the attendants and
ventilation office.\textsuperscript{138}

**THE POST-OCCUPANCY HISTORY OF THE HOUSE OF COMMONS**

‘thermometer tells one tale, and the human body tells another’

John Leslie, 1852\textsuperscript{139}

The previous sections have illustrated how the environmental principles adopted in the House
of Commons reflected a deep concern about the MPs’ perceived thermal comfort, but how
effective were they in achieving Reid’s objective? Over the period between February 1852
and April 1854, which could be described as the post-occupancy phase in the history of Reid’s
system, meeting the MPs’ expectations became an unsurmountable challenge, which also
drove the system being decommissioned and replaced after only two years.

**AN UNSUCCESSFUL FIRST TRIAL**

On 3 February 1852 the New House of Commons was formally inaugurated and the system
went operational for the first time. It was a difficult first day for Reid and his team of attendants.
Failing to maintain comfortable indoor conditions, they received numerous complaints from
MPs. On the following day it also became the subject of a debate, during which MPs described
their experience. Joseph Hume, MP for Montrose Burghs, for instance, reported that he left
the chamber as he could not bear the heat and asked for measures to ‘keep the place

\textsuperscript{138} Notes on drawing dated 6 November 1852: Reid DB, Plans of Offices for ventilation, 22 September 1851, PRO:Work
29/3106

\textsuperscript{139} Oral statement given by John Leslie, 27 April 1852 HC 402 Ev 423-430 Q3137-73.
moderately cool'.

Captain Fitzroy mentioned that MPs were exposed ‘to puffs of alternate hot and cold air’. Ralph Bernal Osborne, MP for Middlesex, moved for Reid to be questioned at the bar of the House. Hume, the Sergeant-at-Arms, and Fitzroy argued that it was complex problem that required a full technical inquiry under the direction of a Select Committee. The First Commissioner of Works Lord Seymour tried to calm the House by stressing that ‘the ventilation was not yet brought to full perfection, so that it could not be said to have had a fair trial’. On 6 February the House voted for a Select Committee and also invited Reid to give a verbal statement at the bar. He became very defensive, claiming that problems were caused by factors outside his control.

He said:

‘doors were torn off in some passages leading to the House, from which gusts of air came into the house from every side. You might as well ask me to regulate the winds and currents of the Bay of Biscay, as expect me to ventilation the house if the doors and windows of the entrances leading to the house are not placed under my control.’

On 7 February Reid submitted a memorandum to the Office of Works outlining the problems and proposals for remedial measures. In this memorandum and another letter from 14 February, he argued that his system was not working effectively as the two supply fans could not be fully deployed. The fan for the floor level supply was operated only manually without the steam engine. It was removed after preliminary tests before the opening as its noise was disrupting debates. The second fan could not be deployed as the downward supply through the ceiling was obstructed by the heat of the gas chandeliers. On 3 February

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141 Times, 9 February 1852, ‘The science of ventilation has at length been’, 4
142 Builder, 14 February 1852, ‘Editorial’, 97
143 Reid DB, Memorandum, 7 February 1852, PRO: Work 11/14, 678; Hansard HC Deb, vol. 119 cols. 231-4 231, 06 February 1852
144 Commissioners of Works, Letter to Barry C, 14 February 1852, PRO: Work 11/14, 679
145 Reid DB, Letter to Department of Woods, 3 December 1851, PRO: Work 11/16, 61; Barry C, Letter to Commissioners for Completion, 3 July 1851, PRO: Work 11/14, 643; Hansard HC Deb, vol. 119 cols. 400-16, 11 February 1852
146 Reid DB, Memorandum, 7 February 1852, PRO: Work 11/14, 678,
the ceiling supply had to be suspended after a brief trial as it carried hot air into the body of the House. The downward supply was only used during daytime debates, when artificial lighting was not required.\textsuperscript{147}

Further complaints were made during the debate on 10 February. Apart from the atmosphere being too hot, MPs complained about ‘tremendous draughts of cold air.’ In the galleries the heat was particular intense due to the chandeliers. These not only raised the air temperature in the upper part of the chamber but also produced a strong radiant heat.\textsuperscript{148} On the next day Osborne persuaded the House to consider Reid’s proposal for improvements, which included a new lighting system that was compatible with the downward supply. Reid was asked to produce detailed plans and estimates to be reviewed by the Select Committee in March.\textsuperscript{149}

Being a major cause of discomfort, permission to improve the lighting was granted to Reid straight away. Alterations to the lighting, however, were stopped by Barry, who insisted that the chandeliers, being an integral part of the architecture, should be retained.\textsuperscript{150}

MPs continued to voice their discontent with Reid’s system and on 12 March the House voted for an independent technical study.\textsuperscript{151} Lord Manners, who had succeeded Seymour as First Commissioner, recommended Goldsworthy Gurney.\textsuperscript{152} Gurney, assisted by Denham Jephson-Norreys from the Select Committee, took initial spot measurements during the sitting on 19 March to examine the conditions inside the galleries. On the main floor the temperatures were as low as 61.5\textdegree F but they rose to 68\textdegree F on the gallery floor and 73\textdegree F above the seats. In addition, Norreys reported, the chandeliers produced ‘a burning sensation, such as if I were

\textsuperscript{147} Oral statement given by Reid (20 April 1852 HC 402 Ev 280 Q1996-7)
\textsuperscript{148} Hansard HC Deb. vol. 119 cols. 400-16, 11 February 1852
\textsuperscript{149} Reid DB, Report of measures required for the health and comfort of the House of Commons, 10 March 1852, PRO: Work 11/14, 711-14
\textsuperscript{151} Hansard HC Deb. vol. 119 cols. 231-4 23, 16 February 1852; Hansard HC Deb. vol. 119 cols. 162 - 72, 4 February 1852: Hansard HC Deb. vol. 119 cols. 400-16, 11 February 1852; Builder, 14 February 1852, Editorial, 97.; Daily News, 5 February 1852, ‘Imperial Parliament’, 3
\textsuperscript{152} Hansard HC Deb. vol. 119 cols. 1147-50, 16 March 1852
exposed to a red hot iron. Log-book entries for the period from 22 March to 23 April 1852 show that the temperature in the galleries fluctuated from 63°F to 73°F (23°C) and was typically 2°F to 6°F above those on the main floor (62°F-70°F). [Figure 22] In the light of modern standards peak temperatures of 73°F (23°C) do not appear exceptionally high. It has to be noted that the Victorian MPs wore heavy clothing and had preferences for lower temperatures. Records of the set temperature for the Permanent House could not be found, but in the Temporary House of Commons attendants were required to maintain levels of 60°F to 63°F in winter and prevent temperatures from exceeding 67°F in Summer. Gurney referred to 64°F as the ‘most satisfactory temperature’. To fully understand the level of perceived discomfort, however, it is critical to consider other environmental factors affecting thermal comfort, such as radiant temperature, relative humidity or air movement, which were not routinely measured. Humidity was only regularly recorded from December 1853. The physicians Neil Arnott and John Leslie, who reviewed Reid’s monitoring system, emphasized that the measuring of air temperature was insufficient to gain insights into the thermal sensations MPs were actually experiencing, in particular the effect of air currents. As currents remained undetected, MPs felt uncomfortable even when the temperatures were within the recommended range.

THE FIRST INDEPENDENT EXAMINATION

Between March and April 1852 Reid’s system underwent a detailed performance evaluation, coordinated by the Select Committee with the engineers Joseph Locke and Robert Stephenson as technical advisors. Interviews and two independent technical examinations were undertaken to gain a deeper understanding of the climate conditions and the MPs perceptions. One study was conducted by Gurney, the other by the architect Samuel Whitfield.

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154 Note: Modern standards recommend temperatures of 20°C to 23°C in winter and 22°C to 26°C in summer (ASRAE, 2004), but if historic clothing levels are taken into consideration these lower temperature come very close current standards. 19th century paintings suggest that clothing levels were approximately 1.5 clo. According to ASHREA Standard 55, at clothing levels of 1.5 clo a temperature of 65°F is optimal for thermal comfort (Bradshaw V 2006, 15-16)
155 Oral statement given by Goldsworthy Gurney (8 May 1854 HL 384 Ev 66 Q675)
156 Oral statement given by Goldsworthy Gurney (23 May 1854 HC 270 Ev 4 Q211)
157 Oral statement given by John Leslie (27 April 1852 HC 402 Ev 423-4 Q3137-43)
Daukes and the heating engineer Henry Cruger Price. The committee interviewed the Speaker, Sergeant-at-Arms and five MPs on the environmental factors affecting their experience. Thomas Thornton reported that temperatures were unsteady and that strong currents frequently swept over the galleries. In 'some parts of the evening', he noted, 'the temperature is very high, and others comparatively low'. The Clerk of the House of Commons highlighted problem with the air being too dry, causing MPs to 'cough, and considerable irritation in the chest and throat'. The latter was also observed by the Sergeant-at-Arms and the Speaker reported a particularly severe instance on 24 March:

'I sent once or twice to Dr. Reid to beg that he would make some change in the state of the air, for it was so dry that it caused an irritation in the throat, and I could hear the Members coughing all around\textsuperscript{160}

The study by Daukes and Price confirmed that the climate was unstable and found that the ventilation rate was often insufficient, at other times became excessive resulting in uncomfortable currents. They claimed that it was caused by managerial problems. Daukes observed that cold and hot air entered House as separate currents, creating an uneven temperature across the floor, and also that currents could suddenly change between hot and cold when valves were switched. Cold and hot air were not sufficiently mixed.\textsuperscript{161} In their final report Daukes and Price argued that Reid's control regime was impractical and recommended simplifications. The latter included abandoning the practice of adjusting climates to the 'continual and conflicting wishes of individual members'.\textsuperscript{162}

\textsuperscript{158} Oral statement given by Thomas Thornton (25 March 1852 HC 402 Ev 4-6 Q28-29)
\textsuperscript{159} Oral statement given by the Clerk of the House of Commons (25 March 1852, HC 402 Ev 16-18 Q124-38)
\textsuperscript{160} Oral statement given by the Speaker of the House of Commons (26 March 1852 HC 402 Ev 45 Q316)
\textsuperscript{161} Oral statement given by Daukes S (5 April 1852 HC 402 Ev 249 Q1729)
Gurney came to similar conclusions. In his first report, dated 6 April, he wrote that the simultaneous extraction and supply of air through the floor and ceiling was difficult to coordinate.\footnote{Gurney G, First Report on the ventilation of the new House of Commons, 6 April 1852, in GB. Parliament. 1852a, 586.} He further examined this issue with the assistance of the engineers James Mather, James Hann and John Hutchinson, which involved tests with differential barometers and anemometers. In his second report published on 13 April Gurney reported that the ventilation rate was insufficient to counteract overheating,\footnote{Gurney G, Second report on the ventilation of the new House of Commons, (HC 1852, 252-371)} and that the atmospheric pressure inside the chamber was lower than outdoors, causing air to enter with great force when doors were opened. His diagnosis was that the quantity of vitiated air extracted through the up-cast shaft was not matched by the fan-driven supply. The fans were introduced by Reid with the intention of maintaining the balance artificially. Air was to be blown in with 'such a force that the air shall have equal pressure within and without',\footnote{Oral statement given by Reid (26 July 1842 HC 536 Ev 6 Q4-10)} but Gurney claimed that the fan and stack were difficult to synchronise effectively. He proposed to adopt a purely-stack driven system in which fresh air was able to enter naturally responding to the pull induced by the up-cast shaft.\footnote{Oral statement given by Goldsworthy Gurney (1 April 1852 HC 402 Ev 130-1 Q821-8)} After these inquiries, the Select Committee authorized Reid to implement alterations outlined in his memorandum and overturned Barry’s earlier rejection of the new lighting system.

**REID’S SYSTEM GETS ANOTHER TRIAL**

The original lighting was designed by Barry and Michael Faraday to harmonize with the gothic detailing. It comprised six gas chandeliers that were hung around the horizontal section of ceiling.\footnote{Illustrated London News, 7 February 1852, ‘The New House of Commons from the Bar’, 121} [Figure 23] It was adopted after Barry had rejected a different lighting system that Reid had designed in 1848 to be compatible with the ceiling supply. Details showing how the lighting was to be integrated into the ceiling were submitted to the Office of Woods on 10 March 1848. Aiming to cast the whole chamber in a soft and uniform light the entire ceiling
was to be covered with 336 small lights. The conical light reflectors were to be inserted into the centre of each ceiling panel. The cones terminated in flues connected to the up-cast shaft. Fresh air was supplied downwards through gaps around the edge of each ceiling panel, whilst the up-cast shaft ensured that fumes were instantly evacuated before they could contaminate or overheat the supply air. [Figure 24]

These drawings were forwarded to Barry on 22 March 1848, who in several letters to the Office of Woods opposed Reid’s involvement in the design of lighting and rejected his scheme for interfering with the architecture of the ceiling. Instead he advocated the use of self-ventilating gas chandeliers that Michael Faraday had developed for the House of Lords, where fresh air was also supplied downwards through the ceiling. The issue was the subject of negotiations for nine months, but at the end Barry persuaded the Commissioners to adopt Faraday’s system. Reid wrote several very emotional letters warning the Commissioners that the lighting and ventilation need to be designed as an integrated system.

The problems encountered in February 1852 show that these warnings were not unjustified and Lord Seymour saw it as a manifestation of insufficient cooperation in the design. Reid argued that it could be resolved by returning to his original plans, but the new lighting installed during the Easter Recess of 1852 neither adhered to his original plans, nor did it facilitate the use of a downward supply through the central panels. Instead he re-organized the ceiling.

168 Reid DB, Statement accompanying Dr. Reid’s Letter to the Commissioners of Woods, 10 March 1848, PRO:Work 11/13, 387
169 Reid, DB, Nine drawings outlining lighting scheme, 10 March 1848, PRO:Work 29/2820-28
172 Reid DB, Letter to Commissioners for Completion, 23 July 1848, Work 11/13, 485
174 Reid DB, Letter to Cole H, 26 April 1848, PRO:Work 11/13, 441-2; Reid DB, Letter Commissioners for Completion, 10 November 1848, PRO:Work 11/13, 527
175 Hansard HC Deb. vol. 119 cols. 400-16, 11 February 1852
176 Reid DB, Letter to Commissioners of Woods, 10 March 1848, PRO: Work 11/13, 391; Reid DB, Statement accompanying Dr. Reid’s Letter to the Commissioners of Woods, 10 March 1848, PRO:Work 11/13, 387
system. The fresh air chamber in the center was converted into a vitiated air chamber and the supply was moved to the sloped side panels. The new vitiated air chamber was connected to the up-cast shaft and gas lights were installed in 16 of the 64 oak panels.\textsuperscript{178} Prints in Illustrated London News show that it was composed of cone-shaped reflectors below which rings with open gas flames were suspended. Instead of being extracted through separate flues, the gas fumes simply rose through the top of the reflectors into the vitiated air chamber.\textsuperscript{179}

A first demonstration of the new arrangements were made during the sitting on 19 April.\textsuperscript{180} Reid claimed that the modification reduced the temperature difference between the floor and gallery to 2F, a claim that the data in the log-books seem to confirm. The largest recorded difference was 3F, compared to 11F(5C) before the alterations.\textsuperscript{181} Temperatures were also consistently lower and more stable. The average daily temperature inside the gallery had fallen by 2F and varied by no more than 4F, compared to 7F before the Recess. In another letter to Office of Works, dated 29 June, Reid stressed that the ventilation had further improved after introducing a new steam engine for the fan driving the floor supply,\textsuperscript{182} but he was still concerned with the state of the system. He wrote that important features were ‘executed promptly and in some cases in a merely temporary manner many arrangements that should now be put on a more systematic and permanent footing.’ Reid received permission to improve the system in September, but he was unable to complete the work before his contract had ended.\textsuperscript{183} When the engineer Alfred Meeson took over his role as superintendent in November, it was still unfinished. Meeson reported that alterations had to be done under time pressure to ensure that sittings could resume on 4 November 1852, which resulted in work

\textsuperscript{178} Oral Statement given by Reid (20 April 1852 HC 402 Ev 279-82 Q1991-2008)
\textsuperscript{179} Illustrated London News, 24 April 1852, ‘Dr. Reid System of Lighting the House of Commons’, 317; Oral statement given by Goldsworthy Gurney (26 April 1852, HC 402 Ev 400 Q2980-2)
\textsuperscript{180} Oral statement given by Goldsworthy Gurney (26 April 1852, HC 402 Ev 288-92 Q2063-92)
\textsuperscript{181} Registers of temperature control and ventilation for the House of Commons 1853-1854, Parliamentary Archives: OOW/5
\textsuperscript{182} Reid DB, Supplementary Report, 29 June 1852, PRO: Work 11/14, 735
\textsuperscript{183} Manners J, Letter to Reid DB, 9 September 1852, PRO:Work 11/16 nr. 747; Reid DB, Letter to Manners J, 27 August 1852, PRO:Work 11/14, 741; Office of Works, Letter to the Chancellor of the Exchequer, Lord John Manners and Earl of Derby, 22 July 1852, PRO:Work 11/16, 68; Phipps, J, Notes on the ventilation work still to be completed, 3 September 1852, PRO: Work 11/14, 744-6
being roughly executed.\textsuperscript{184} Reid was unable to complete his scheme, let alone optimize its performance during the nine months that he was in charge of superintending the day-to-day operations.

**THE SYSTEM UNDER A NEW SUPERINTENDENT.**

Prompted by recommendations of the Committee that the ventilation systems inside the Palace should be placed under one rather two superintendents, Reid’s employment came under review. The ventilation in the House of Lords was supervised by Meeson, who had also worked as Clerk of Works in Barry’s office. In several letters Barry warned Lord Manners that appointing Reid for this new post was a risk and that he was not prepared to tolerate his interference.\textsuperscript{185} Reid in return threatened Manners with legal actions.\textsuperscript{186} Manners discussed this issue with the Exchequer Benjamin Disraeli, the Prime Minister Lord Derby and consulted Stephenson and Locke. The engineers agreed that Reid, despite his expertise in the field of ventilation, was unsuitable due to his inability to cooperate with Barry.\textsuperscript{187} Manners terminated his employment in October 1852,\textsuperscript{188} and transferred responsibilities to Meeson.

Meeson undertook a first survey of Reid’s system in January 1853. In a report to the Office of Works he warned that it was in a poor conditions, preventing it from working effectively. The fan and heating of the ceiling supply was in disrepair and critical features, such as the valves below the floor, were not completed or poorly executed,\textsuperscript{189} causing air to rise through parts of the floor unchecked. Meeson also criticized that the control procedures were too complex as attendants had to undertake large number of operations in different locations.\textsuperscript{190} Meeson considered such operational aspects the main issue with Reid’s system, highlighting that the

\textsuperscript{184} Meeson A, First Report on the State of the warming, and ventilation and lighting of the Houses of Parliament, 8 January 1853 PRO:Work 11/14, 768-81
\textsuperscript{186} Note: In 1853 Reid was paid £3250 in compensation following an arbitration. Gardiner J, Letter to Phipps, J, 9 May 1853, PRO:Work 11/16, 140; Copies of the submission to arbitration between Her Majesty’s government and Dr. Reid. (HC 1852-53 498)
\textsuperscript{187} Locke J and Stephenson R, Report to Commissioners of Works, 3 August 1852, PRO:Work 11/16, 73.
\textsuperscript{188} Commissioners of Works, Letter to Reid, 21 September 1852, PRO: Work 11/16, 81
\textsuperscript{189}Meeson A, Letter to Commissioner of Works, 8 January 1853, PRO: Works 11/14, 767
\textsuperscript{190} Oral Statement given by Alfred Meeson (30 March 1854 HC 149 Ev 15 Q171-4)
temperature was difficult to regulate as the hot-water system could not be adjusted at the required speed to respond to the extreme fluctuation in the number of people. According to the log-books the number could change between 50 and 800 people during a single sitting, resulting in sudden changes in the internal heat load. Temperature control was a major issue.

The Speaker reported that Reid had difficulties managing the heat load during crowded debates, and the Sergeant-at-Arms observed that the temperature and air quality was highly susceptible to changes in attendance. MPs, he noted 'suffered from very high temperatures, which Reid was unable to control; frequently, hour after hour, I have requested him, at the desire of the Members and in accordance with my own feelings, to lower the temperature; he appeared to be unable to do so; it sometimes increased rather than diminished during the progress of the evening'.

Meeson also reported that Reid's lighting system had not resolved the overheating problems inside the galleries, and could only be counteracted through higher ventilation rates, which were neither required to maintain a good air quality nor desirable from the point of thermal comfort. In March 1853 the ‘Standing Committee Report of the Standing Committee on the Ventilating and Lighting the House of Commons’ was appointed to review Meeson's recommendations. It was chaired by the First Commissioner Sir William Molesworth and included Locke and Stephenson as technical consultants. Gurney, who had undertaken lighting experiments inside the Temporary House of Commons, was commissioned to develop a new lighting.

In his plans, presented to the Office of Works on 10 March, the lights were moved into the vitiated air chamber above the ceiling and the wooden panels replaced with panes of painted glass. The fumes from each light were conveyed to the up-cast shaft.

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191 Oral statement given by the Speaker of the House of Commons (26 March 1852 HC 402 Ev 45-6 Q318-28)
192 Oral statement given by the Sergeant-at-Arms (26 March 1852 HC 402 Ev 40-42 Q257-69)
193 Ventilation and Lighting of the House Committee. Standing Committee on the Ventilating and Lighting the House of Commons. Report of the Standing Committee on the Ventilating and Lighting the House of Commons, (HC 1852-53 570) HMSO; Copy of the report of Mr. Goldsworthy Gurney to the Commissioners of Works, respecting the lighting of the House of Commons (HC 1852-53 911) HMSO
194 Hansard HC Deb. vol. 129 cols. 1297-318, 4 August 1853
196 Oral statement given by Goldsworthy Gurney (12 June 1854 HL 384 Ev 95-6 Q931-39)
through separate flues, protecting the firemen and attendants stationed inside the air chamber.\textsuperscript{197} The lights were tested in April and measurements taken by Gurney's assistants reveal that the heat load was phenomenal, causing the temperature in the vitiated air chamber to reach 89\textdegree F (31\textdegree C) to 123\textdegree F (50\textdegree C).\textsuperscript{198} Meeson criticized the system fearing that it could also affect the temperature inside the House.\textsuperscript{199} To dispel such fears, Gurney commissioned the engineers Thomas Mather and James Hann to take measurements inside the debating chamber. Thermometers were hung below the glass panels, but the engineers could not detect any measurable increase, even when the lights were on for longer periods.\textsuperscript{200} Meeson remained skeptical. In his second report he claimed that the lights caused the temperature in the galleries to rise to 74\textdegree F (23\textdegree C).\textsuperscript{201} To address this issue he reactivated the air supply through the side panels, allowing cool air to be delivered directly into the galleries.\textsuperscript{202} During Meeson's administration the ventilation also fell victim to the lack of commitment to Reid's original principles, but abandoned important features, such as the intricate supply and extract arrangements within the floor. Large parts of the perforated floor, intended for the supply and extraction of air was sealed to protect MPs from rising currents.\textsuperscript{203}

THE FINAL ASSESSMENT OF REID'S SYSTEM

After these changes MPs continued to be dissatisfied, which was voiced during debates between May 1853 and March 1854.\textsuperscript{204} John Bright, MP for Manchester and Sir Denham Norreys complained about uneven temperature across the House,\textsuperscript{205} which Richard Spooner, MP for north Warwickshire, described as 'scolding in one part, and freezing in another'.\textsuperscript{206

\begin{thebibliography}{99}
\bibitem{198} Gurney G, Letter to Commissioners of Works, 12 March 1853, PRO: Work 11/14, 784
\bibitem{199} Gurney G, Register of thermometer and pressure gauge, 8 August 1853, in HC 1852-53 911, 4.
\bibitem{200} Thomas Mather and James Hann, Report, 30 June 1853, in HC 1852-53 911, 2-3.
\bibitem{202} Oral Statement given by Alfred Meeson (30 March 1854 HC 149 Ev 12 Q127-34)
\bibitem{203} GB. Parliament. 1852 - 53 ; Oral Statement given by Goldsworthy Gurney, 30 March 1854 HC 149 Ev 3-5 Q 11-25)
\bibitem{204} Hansard HC Deb. vol. 129, cols. 1297-3180, 4 August 1853; Hansard HC Deb. vol. 124 cols. 180-1, 17 February 1853; Hansard HC Deb. vol. 127 cols. 388-422, 19 May 1853
\bibitem{205} Times, 11 March 1854, 'Ventilation of the House', 7; Daily News, 20 May 1853, 'Imperial Parliament', 3
\bibitem{206} Daily News, 1 March 1854, Ventilation of the House, 2
\end{thebibliography}
There were also issues with dust being carried up by currents rising through the floor. These reportedly caused irritations in the eyes and lungs, making it difficult for MPs to speak without drinking water. Spooner instigated several debates and lobbied for adopting the Gurney’s proposed from 1852. He was opposed by Molesworth, who argued that Meeson needed more time to get the system working optimally, yet after nine months of lobbying Spooner’s initiative would ultimate lead to the decommissioning of Reid’s system. On 10 March Spooner made a successful motion for another Select Committee charged with identifying ways of improving the system.

As Member of the committee Spooner continued lobbying for Gurney’s system. The Committee only reviewed Gurney’s earlier proposal and commissioned Gurney to undertake another examination. He presented a proposal two weeks later, which involved substantial remodeling of Reid’s system. On 31 March 1854 the Select Committee published a preliminary report that advocated Gurney’s scheme. It claimed that Reid’s system was ‘condemned by common consent’ as unsatisfactory, and recommended testing Gurney’s scheme after the Easter recess. On 6 April Gurney had a meeting with Molesworth to discuss his proposal and on the following day submitted report on alteration that could be completed over the Easter Recess. His system was only to be trialed, and in case it was unsuccessful they were to revert back to Reid’s system. In two other letters Gurney stressed that more substantial modifications would be needed to fully implement his principles. On 10 April Spooner read the report to the House and moved for the adoption of Gurney’s proposal, which was approved by vote. Molesworth criticized the way the process was handled.

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208 Times, 11 March 1854, ‘Ventilation of the House’, 7
210 GB. Parliament. 1854c, iii-iv.
211 Commissioners of Works, Letter to Gurney, 7 April 1854, PRO:Work 11/14, 850
212 Gurney G, Letter to Commissioners of Works, 7 April 1854, PRO: Work 11/14, 842; Gurney G, Letter to Commissioners of Works, 10 April 1854, Work 11/14, 847
214 Commissioners of Works, Letter to Gurney, 12 April 1854, PRO:Work 11/14, 854.
felt that Spooner was making the House decide before the committee had undertaken a full
inquiry. Its recommendations were based solely on evidence given by Meeson and Gurney.215

GOLDSWORTHY GURNEY’S RIVAL SYSTEM

The alterations required to test Gurney’s system were made between 14 and 26 April and its
performance was reviewed by the House of Commons Select Committees, and another
Committee appointed to review Barry’s system in House of Lords. Having received similar
levels of disapproval to Reid’s system, the Lords also considered adopting Gurney’s
alternative system if the trials in the Commons were successful. MPs were interviewed before
and after the alterations to determine how far Gurney’s system had improved thermal comfort.

For the tests the Clock Tower was converted into the main up-cast shaft, which was used to
extract vitiated air through the centre of the main floor and the central ceiling panels. The
vitiated air from the floor and ceiling was conveyed to the Clock Tower through the former
fresh air passages in the basement. Reid’s original up-cast shaft and roof level inlets were
retained, but the floor level supply was remodeled to allow fresh air to be driven into the House
solely through the pull of the two stacks. Instead of introducing air through remote inlets and
long passages, which required mechanical assistance, fresh air was admitted directly from the
Star Chamber and Commons Courts.216

Gurney also replaced Reid’s hot-water apparatus with a steam heating system to allow the
temperature to be more rapidly adjusted in to response to changes in attendance.217 Much
care was taken in maintaining a narrower range of temperatures and more optimal humidity.218

216 Gurney provided several oral accounts of his scheme in front of the two Select Committees: (30 March 1854 HC 149 Ev 1-
12 Q1-126); (23 May 1854 HC 270 Ev 1-6 Q189-232); (21 July 1854 HC 403 1-4 Q233-73) and (8 May 1854 HL 384 Ev 60-71
Q 617-734)
217 Oral statement given by Gurney (30 March 1854 HC 149 Ev 1-10 Q1-101)
218 Oral statement given by Gurney (8 May 1854 HL 384 Ev 67 Q694)
Attendants were ordered to maintain temperatures between 63F and 64F (17C-18C).\textsuperscript{219} The internal currents were also monitored using down feathers that were attached to strings suspended across the chamber.\textsuperscript{220} The logbooks did not include measured data for this period, but interviews with MPs between May and July 1854 suggest that the climatic had significantly improved. The Sergeant-at-Arms reported that the temperature was more tightly managed, draughts markedly reduced and the atmosphere felt fresh even after long debates.\textsuperscript{221} According to Robert Smith, MP for Northampton, the atmosphere was fresher and did not become oppressively hot.\textsuperscript{222} The MP for North Riding noted that draughts only occurred occasionally,\textsuperscript{223} and Edward Bouverie, MP for Kilmarnock Burghs, found that the attendants were able to adjust the temperature more quickly.\textsuperscript{224} In its second report, dated 26 May 1854, the Select Committee formally announced the end of Reid's system. It concluded that Gurney's interventions were successful in improving thermal comfort and recommended that the system to be permanently adopted. It wrote that MPs perceived the atmosphere as ‘sensibly sweeter, fresher and purer’ and that the temperature was under tighter control.\textsuperscript{225} The House of Lords was also remodeled following Gurney’s principles.\textsuperscript{226}

**CONCLUSION: THE RISE AND FALL OF REID’S LEGACY**

This article retraced how Reid's masterplan for the ventilation of the Palace of Westminster had evolved and illuminated the role of empirical observations in addressing fundamental technical and human aspects of environmental design. Focusing on human aspects these inquiries exemplified how his medical background influenced his approach to environmental design that was distinctive from the more technical focus of civil engineering. MPs were directly involved in evaluating and refining the environmental systems from a thermal comfort

\textsuperscript{219} GB. Parliament. 1854b, iii-iv.
\textsuperscript{220} Oral statement given by Gurney (23 May 1854 HC 270 Ev 4 Q206-9; Oral statement given by Gurney (8 May 1854 HL 384 Ev 61-66 Q618-81, Times, 28 April 1854, ‘House of Commons, 27 April’, 3; Morning Chronicle, 29 April 1854, ‘The New House of Commons’, 5
\textsuperscript{221} Eyewitness account given by the Sergeant at Arms (15 May 1854 HL 384 Ev 83-4 Q839-51)
\textsuperscript{222} Eyewitness account given by Robert Vernon Smith MP (3 July 1854 HL 384 Ev 99-100 Q963-73)
\textsuperscript{223} Eyewitness account given by Edward Cayley MP (3 July 1854 HL 384 Ev 100-103 Q973-94)
\textsuperscript{224} Eyewitness account given by Edward Bouverie MP (12 May 1854 HL 384 Ev 73-76 Q753-9)
\textsuperscript{225} GB. Parliament. 1854b, iii-ix.
\textsuperscript{226} Gurney G, Letter to Francis Stone, 17 June 1854, GB. Parliament. 1854a, 118.
perspective. This included the inquiries into environmental monitoring regimes that were responsive not only to physical measurements but also the MPs’ perceived comfort or air quality. These inquiries culminated in the highly sophisticated system of the Permanent House of Commons.

Its design, however, cannot be understood through these scientific inquiries alone as it was also influenced by the political context. Important features, such as the lighting system or air supply, were the outcome of intense negotiations, Reid’s power struggle with the architect. Over the short period in which Reid was in charge of running the system, he was also unable to complete, let alone optimize the design and operational procedures. Meeson, who succeeded Reid as superintendent, did not continue his efforts to realize the sophisticated strategy. When Gurney undertook the last test of Reid’s system in 1854, most the perforated floor intended for the supply and extraction of air had been sealed. It was therefore never proven whether Reid’s strategy could have worked.

From 1852 to 1854 Reid’s system was subject to continuous scrutiny from scientists, parliamentary committees and individual MPs. Evaluating its performance became a political process, not the least as the MPs were exceptionally powerful occupants, who regularly voiced their discontent and demanded measures to improve thermal comfort. Reid, Meeson and Gurney were confronted with the challenge of devising a system that satisfied the MPs. The occupants’ perception, rather than physical measurements, became the ultimate measure by which Reid’s system was evaluated. Several scientific studies were conducted, which, similar to modern Building Performance Evaluations, combined physical measurements and experiments with qualitative interviews reviewing the occupants’ experience. 227 Reid anticipated the concept of an intelligent system that was responsive to feedback gained through measurements and subjective responses from occupants. Historic records, however,

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suggest that it was too complex to be operated entirely manually without modern computerized controls, electronic sensors or actuators. Attendants had difficulties with collecting and processing large quantities of data at the required speed, alongside operating the heating and ventilation. Environmental control was an elaborate manual procedure, which relied on the skills and diligence of the attendants.

Reid's work at the Palace of Westminster, featuring extensively in the American and European technical literature, had a strong influence on the nineteenth century discourse within the field of heating and ventilation. This article, however, has revealed that Reid's lasting contribution to the ventilation of the Palace itself was limited and his legacy short-lived. His responsibility was confined to the House of Commons, accounting only for a small area of the Palace. Working with other engineers, Barry developed most of ventilation in the Palace. The numerous ventilation shafts on the roof, including the three gothic turrets above the river front, were added by Barry. Barry's team retained and incorporated some features of Reid, such as parts of central air supply served by the Victoria Tower. Although reduced in size and no longer serving as a central outlet, the Central Tower was initial retained as a local shaft for the House of Lords. It became redundant after 1854 when Gurney converted the Victoria Tower into the up-cast shaft instead. Taking a term from evolutionary biology, it could be understood as a vestigial of the Palace's design evolution.

Failing to satisfy the MPs from a thermal comfort perspective, Reid's system was replaced with a new system. This was in continual use for ninety years during which it underwent various technical refinements. Although Barry's system was also remodeled following Gurney's approach, his ventilation turrets remained in use. Therefore it could be argued that Gurney and Barry had a more lasting influence. The fact that only a few features of Reid's

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228 Billing J 1876, 11-29; Wyman M 1846, 214-19; Tomlinson R 1846, 182-212; Bernan W 1844, 39-44; 94-104; Richie R 1862, 177-8; 190-1
system had survived beyond the 1850s might suggest that previous studies overemphasized the level of Reid's contribution. However, it could also mean that his legacy can only be fully understood if read as a contribution to a system that was continuously evolving, with various features being reshaped by subsequent generations of scientists and engineers.³

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¹ Reid, Illustrations, p. xvi, Brief outlines, p. 1; American Dwelling, p. xxv.
² Letter from Barry to Lord Duncannon, 3 October 1839, in Third Report (HC 1846 574), pp. 21-22

ABBREVIATIONS:

PED: Parliamentary Estate Directorate

PRO: National Archives

Commissioners of Woods: Commissioners of Woods and Forests

Commissioners for Completion: Commissioners for the Completion of the New Palace of Westminster.

HLRO: Parliamentary Archives (formerly House of Lords Record Office)

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